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RESEARCH BRIEF



New Research at Paisley Caves: Applying New Integrated Analytical Approaches to Understanding Stratigraphy, Taphonomy, and Site Formation Processes

Lisa-Marie Shillito ^a, John C. Blong ^a, Dennis L. Jenkins^b, Thomas W. Stafford Jr^c, Helen Whelton^d, Katelyn McDonough ^e, and Ian D. Bull^d

^aSchool of History, Classics and Archaeology, Newcastle University, Newcastle Upon Tyne, UK; ^bMuseum of Natural and Cultural History, University of Oregon, Eugene, OR, USA; ^cStafford Research, Denver, CO, USA; ^dOrganic Geochemistry Unit, School of Chemistry, University of Bristol, Bristol, UK; ^eDepartment of Anthropology, Texas A&M University, College Station, TX, USA

ABSTRACT

Paisley Caves in Oregon has become well known due to early dates, and human presence in the form of coprolites, found to contain ancient human DNA. Questions remain over whether the coprolites themselves are human, or whether the DNA is mobile in the sediments. This brief introduces new research applying an integrated analytical approach combining sediment micromorphology and lipid biomarker analysis, which aims to resolve these problems.

KEYWORDS

Micromorphology;
biomarkers; Paisley Caves;
Great Basin

The Five Mile Point Paisley Caves are located in south-central Oregon in the northern Great Basin (Jenkins 2007). Research conducted there provides the earliest well-accepted evidence for human settlement of the Great Basin, including culturally modified bone, lithic tools, and human coprolites recovered in association with Pleistocene large mammal remains. Radiocarbon analysis of the coprolites indicates humans occupied the cave as early as 14,300 cal yr BP (Gilbert et al. 2008; Hockett and Jenkins 2013; Jenkins 2007), with periodic occupation from 14,300 cal yr BP through the historic period (Jenkins 2007; Jenkins et al. 2012, 2013).

The earliest date was obtained from a coprolite dated between 14,170 to 14,340 cal yr BP, which was found to contain ancient human DNA (Gilbert et al. 2008); however, questions have been raised over the aDNA recovery and stratigraphic integrity (Poinar et al. 2009). It has also been argued that microscopically, the coprolites resembled animal rather than human feces (Goldberg, Berna, and Macphail 2009). The latter was based on comparison of the Paisley coprolites with those of Viking humans and modern camels. With a subject that attracts great academic and public interest, it is important that such evidence is scrutinized, but there are aspects of this criticism which are flawed. Comparing Palaeoindian and Viking samples does not take into account major dietary differences between these populations, or the different preservation contexts and diagenetic processes. Previous research has demonstrated that microscopic

methods are not a reliable way of identifying the species of coprolites; prehistoric coprolites from Turkey, identified as animal on the basis of inclusions (i.e., bone fragments and plant tissues), in fact contained distributions of sterols and bile acids indicative of a human source (Shillito et al. 2011).

In our ongoing study, we are using sterols and bile acids (lipids) as a species indicator, as the sterol profile varies according to whether an organism has a meat-dominant, omnivorous, or herbivorous diet, whilst the bile acid profile is distinct to particular species. Human coprolites are distinguished by the presence of lithocholic acid and deoxycholic acid, with a dominance of the former (Bull et al. 2002). Sistiaga et al. (2014) analyzed one coprolite from Paisley Caves and argued that the sterol profile was consistent with an animal origin, but their analysis neglected to make a parallel analysis of bile acids, which are necessary for separating humans from other omnivores and herbivores. Their conclusion also does not take into account the fact that meat may have been a minor or seasonally variable dietary component of early populations. Moreover, results from a single coprolite cannot be extrapolated to the entire occupational history of the caves. An archive of over 1800 coprolites throughout the Paisley Caves sequence provides an opportunity to examine changes in diet at a high resolution, as well as to provide information on species lipid biomarkers in coprolites, in combination with microfossil analyses, allowing

CONTACT Lisa-Marie Shillito  lisa-marie.shillito@ncl.ac.uk

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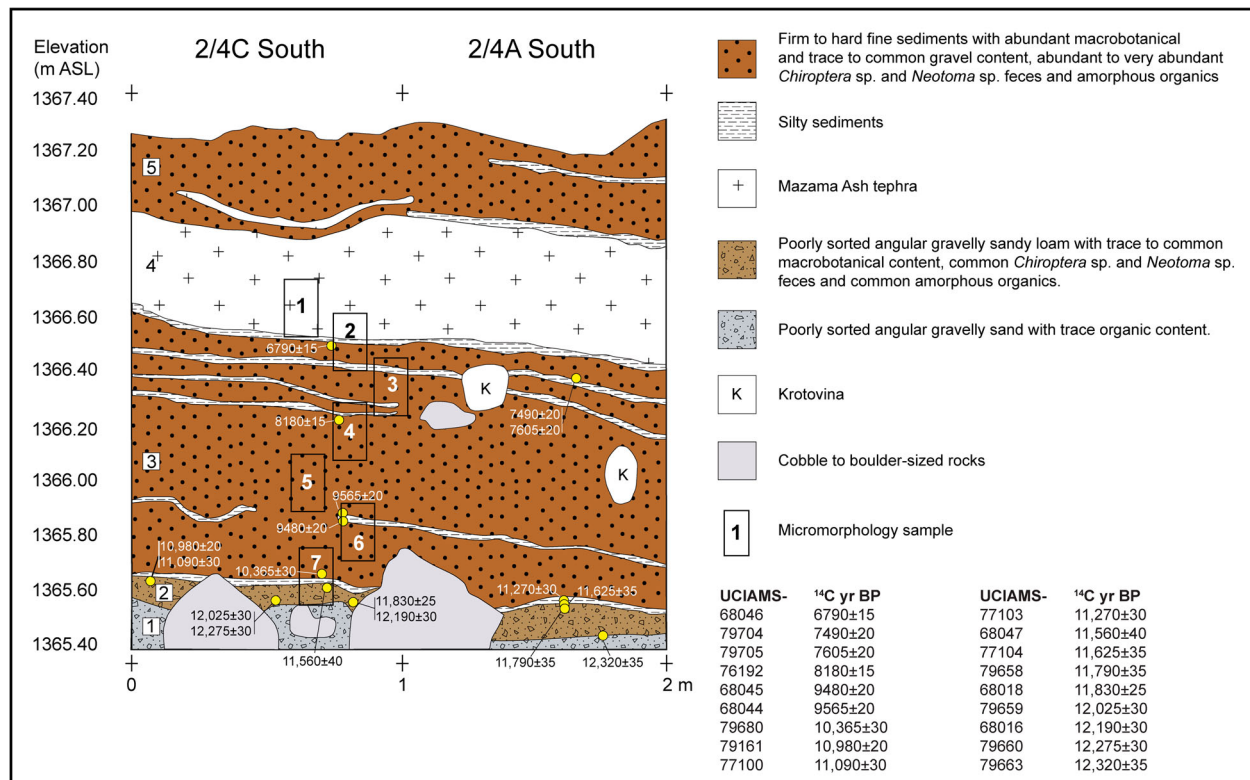


Figure 1 Profile from Cave 2 of the Paisley Caves, Unit 2/4C, showing location of pilot study micromorphology blocks (adapted from Jenkins et al. 2012).

inferences on dietary inputs. Recent investigations of microfossils including phytoliths and starch grains have shown promise for providing detail on the plant component of diet in this region (Herzog 2014; Louderback and Pavlik 2017; Morris et al. 2009).

Any study using sterols as dietary indicators must take into account dietary composition. Sterols by themselves only give an indication of the broad dietary inputs, i.e., whether there is an emphasis on plants or meat. A more holistic approach, incorporating the analysis of other lipid compounds extant within the coprolite, will

provide a better indicator of dietary composition. The earliest subsistence data for the Great Basin indicates that Pleistocene foragers had a diverse diet consisting of a variety of medium-sized mammals, birds, insects, fish, shellfish, and plant resources (Goebel et al. 2011; Hockett 2007; Rhode and Louderback 2007). Pleistocene foragers in the Great Basin may have targeted lower-ranking resources such as plants and seeds when higher-ranking foods were unavailable, and there were likely periods when their diet consisted mostly of plant resources (Grayson 2011, 302).

Table 1 Micromorphology samples collected from Cave 2, Unit 2/4C.

Slide	Field description	Preliminary micromorphology summary observations	Associated date (cal yr BP, approximate; from Jenkins et al. 2012)
2	Mazama ash and underlying layers	Biogenic with mix of plant tissues, micro bone fragments, with discontinuous lenses of water laid sediments in lower part	6790
3	Silt lenses, softer top layers, firm middle lenses, softer lower layers with hard "fleks"	Alternating mixed windblown debris and alluvial lenses, increased biogenic component in lower part	7490–8180
4	Underlying slide 3, hard "fleks", looser at base	Continues biogenic material from base of slide 3, shifts to mixed microfaunal pellets with larger mammal pellet present	8180
5	Continues sequence between 4 and 6	Majority of deposit microfaunal pellets, occasional plant tissues and bone with areas showing calcite coatings. Shifts to mixed pellet/windblown sediments at base	8180–9565
6	Another silt lens	Shift to fine grained silts and clay mixed with sub-rounded sand grains and basalt from cave wall/roof	9480–9565
7	Oldest deposits at base of slide	Increased frequency of large basalt fragments, mixed biogenic and minerogenic material, with occasional charcoal fragments towards base	11,560–12,275

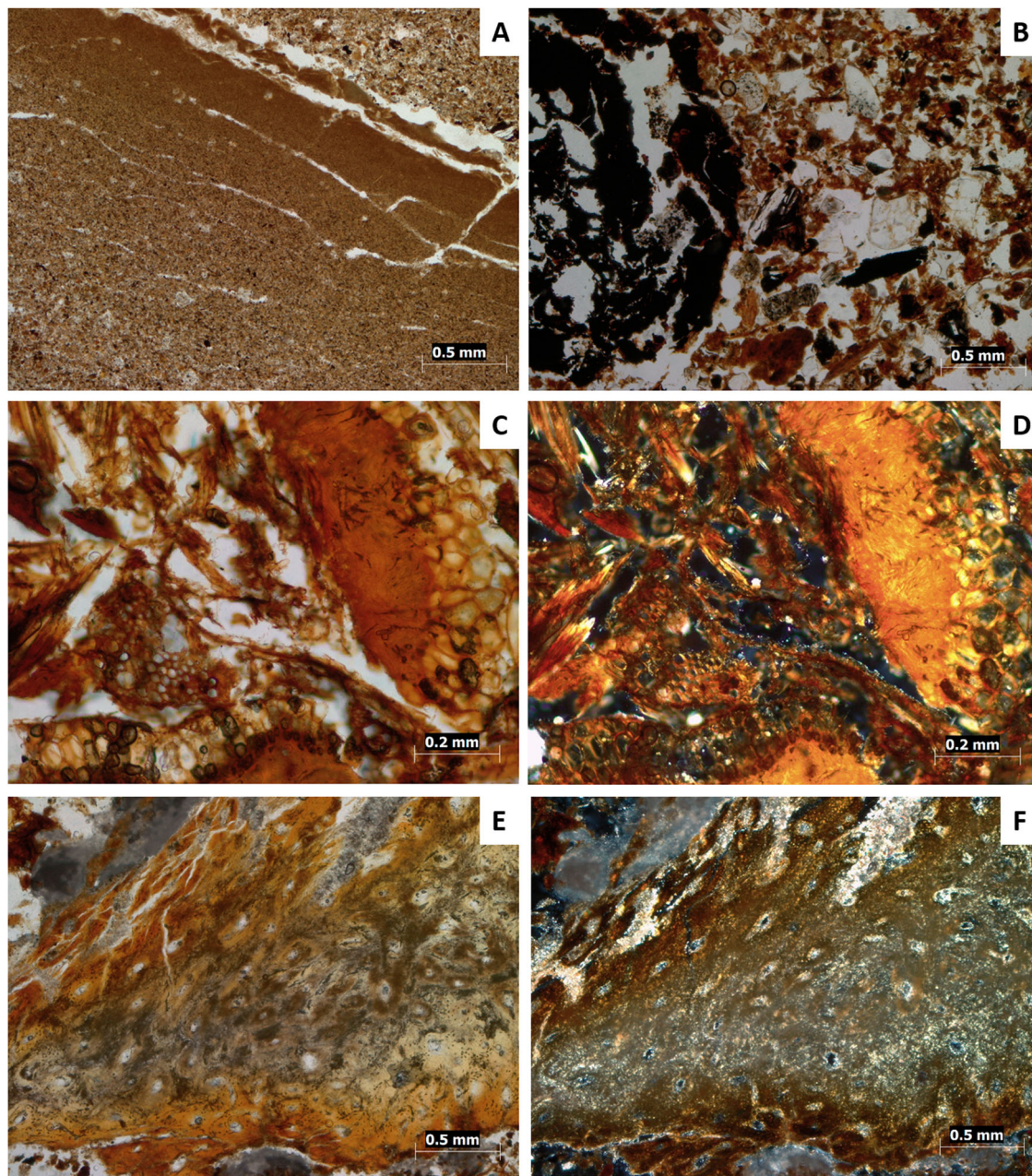


Figure 2 Thin section micrographs showing (A) water-lain sedimentary crust of silt lens slide 3; (B) charcoal fragments slide 7; (C) preserved plant tissues in dung pellet slide 4 in PPL; (D) showing same as C in XPL highlighting cellulose preservation; (E) bone fragment showing signs of dissolution and calcite hypocoating; (F) showing same as E in XPL highlighting calcite hypocoating.

While limited to a few samples, previous studies at the Paisley Caves also indicate the potential that coprolites hold for reconstructing past human subsistence. Pollen, phytolith, faunal, macrobotanical, Fourier-transform infrared spectroscopy (FTIR), and protein residue analyses conducted on coprolites from the earliest occupation of Paisley Caves provide evidence for consumption of large, medium, and small mammals, as well as birds and plant resources (Aikens, Connolly, and Jenkins 2011, 59; McDonough et al. 2012). On a broader scale, microfossil, macrofossil, and lipid analyses

of coprolites recovered from dry cave settings throughout the Great Basin provide important direct evidence of prehistoric subsistence patterns (Callen and Martin 1969; Eiselt 1997; Fry 1976; Holm 2013; Martin and Sharrock 1964; Neumann, Holloway, and Busby 1989; Rhode 2003). Palynological studies conducted on sediment samples from the Paisley Caves indicate the potential of pollen analysis for paleoenvironmental reconstruction, and microfauna proxies also provide insights into local paleoenvironment (Beck, Bryant, and Jenkins 2017; Karkanas and Goldberg 2013;

McGuire, Davis, and Brett Riddle 2013; Saban 2015; Saban and Jenkins 2013).

By combining lipid biomarkers with analysis of microfossils and macrofossils, we are working to provide a comprehensive analysis of all the dietary information contained within a single coprolite and separate animal from human. As coprolites are produced over a short period within the body, they provide dietary information at a very high temporal resolution, contrasting with traditional dietary proxies in archaeology such as skeletal C/N isotopes, which give an average lifetime signal. An advantage of lipid biomarkers, compared to aDNA, is that lipids can be directly dated using compound-specific ^{14}C dating of individual lipid molecules. Rather than dating bulk carbon within a macro sample, compound-specific data isolate individual compounds and provide a direct date on the carbon from that compound only (Roffett-Salque et al. 2016). The combination of compound-specific radiocarbon dating and seasonal micro/macrofossil dietary “packages” provide a very high resolution chronology, an analysis of resource use and human-environment relationships, and how these change over the long-term occupation of the site.

Besides providing a new approach to the study of early diets, we are addressing potential movement of molecules within the cave sediments by integrating sediment micromorphology with lipid analysis of the sediments from which coprolites are recovered. Whilst analysis of biomolecules is indicating variability in concentration throughout the sediment profile, micromorphology is revealing the physical processes by which they are moving. Our preliminary analyses have indicated that sedimentation processes at the site are complex, consisting of multiple episodes of aeolian and alluvial inputs interspersed with periods of human activity. Material eroding from the cave roof and walls is distributed throughout the sediments. Further build up is seen through accumulation of rat midden and associated burrowing. Whilst areas of intact deposits are present, it is possible bioturbation or other post-depositional processes are happening at the microscale. A series of overlapping micromorphology block samples have been collected covering the entire stratigraphic sequence in Caves 2 and 5 (Figure 1). Initial observations of the first sequence from Cave 2 (Table 1) have indicated multiple episodes of inwash resulting in waterlain silt lenses (Figure 2(A)), with further features such as calcite coatings indicating water movement and translocation of fine material (Figure 2(E,F)). These observations provide important clues about the complex taphonomy within the caves’ sediments, and will be invaluable in helping understand the distribution of lipid biomarkers in the sediments.

If their movement is found to be restricted, as is seen in experimental studies of soil lipids (Bull et al. 2000), we plan on using compound-specific radiocarbon dating of human fecal biomarkers in the absence of discrete coprolites to give a more precise date for the human presence in the cave. Whilst lipids are likely to be relatively stable, our observations have implications for aDNA, given that it is a much more mobile molecule.

Disclosure statement

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ORCID

Lisa-Marie Shillito  <http://orcid.org/0000-0002-6176-531X>
John C. Blong  <http://orcid.org/0000-0002-3868-807X>
Katelyn McDonough  <http://orcid.org/0000-0002-6176-531X>

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